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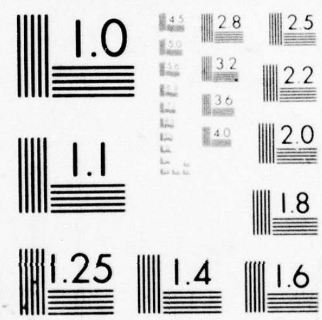

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LOCKHEED

MISSILES & SPACE COMPANY, INC. • SUNNYVALE, CALIFORNIA

A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION

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402654

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FOREWORD

ABSTRACT

This is the final technical report describing the work accomplished and goals met for Contract DAAK70-76-C-026.

The objective of this project was to design and build two (2) low-power eye-safe laser ranging units and two (2) cooperative targets for installation on Aquila RPV Phase IV/V sensor payloads for utilization on the Aquila RPV program.

The low-power lasers provide the Army with a means of training personnel to perform laser oriented missions without the extreme ocular hazards that are associated with the present high power YAG laser utilized on the Aquila program.

UNDER CONTRACT TO

Department of the Army, U.S. Army Mobility Equipment Research and Development Command, Fort Belvoir, Virginia 22060;

- Ana R. Purcell, DRXFB-PR-3, Contracting Officer
- James E. Miller, DRSEL-NV-II, Contract Technical Representative
- T. D. Gossett, AMRDL Representative
- O. T. Osborne, AFPRO/LMSC-TMD, Administrative Contracting Officer

CONTRACTOR

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Section 1

INTRODUCTION AND SUMMARY

4

High-power, Class ~~IV~~ lasers are utilized on the Aquila mini-RPV program to accomplish target location, artillery adjustments, and laser target designation.

Lasers are classified by their capability of injuring personnel. Class IV laser radiation is hazardous to the eye from direct beam viewing, and from specular and diffused reflections.

The nominally-calculated Ocular Hazard Range for the Aquila YAG laser is 20 Km. This is only nominal, as the use of optical viewing instruments, within the beam, will extend this hazard distance considerably. Also, because of atmospheric effects upon the beam, calculation of a single "Hazard Range" for safety purposes is not feasible.

4/5 LMSC proposed to design and build an eye-safe, Class 1, low-power, GaAs ranging laser. This laser would be compatible with the Aquila Phase ~~III~~ 3, ~~IV/V~~ sensor platforms and could be directly substituted for the high power YAG laser on the Phase ~~IV/V~~ 4/5 sensor platform.

The eye-safe laser ranging unit proposed by LMSC, when used with a ground located cooperative retroreflective target, would provide the Army with an excellent training simulator for RPV laser operations.

LMSC received Contract No. DAAK70-76-C-0256 to provide the Army with two (2) eye-safe laser ranging units and two (2) cooperative retroreflective targets.

LMSC designed, built, successfully field tested, and delivered the above hardware and all of the proposed design goals were substantially exceeded.

The design approach of the laser ranging unit was based upon the Aquila Phase IV mission requirements of target location and artillery adjust-

ment. Figure 1.1 illustrates a typical mission scenario and Figure 1.2 illustrates the laser ranging unit's location on the Aquila RPV.

The cooperative target utilized with the eye-safe laser ranging unit is depicted in Figure 1.3.

Figures 1.4 and 1.5 are photographs of the actual hardware delivered installed on a Phase IV sensor platform.

ARMY TARGET LOCATION AND ARTILLERY ADJUSTMENT

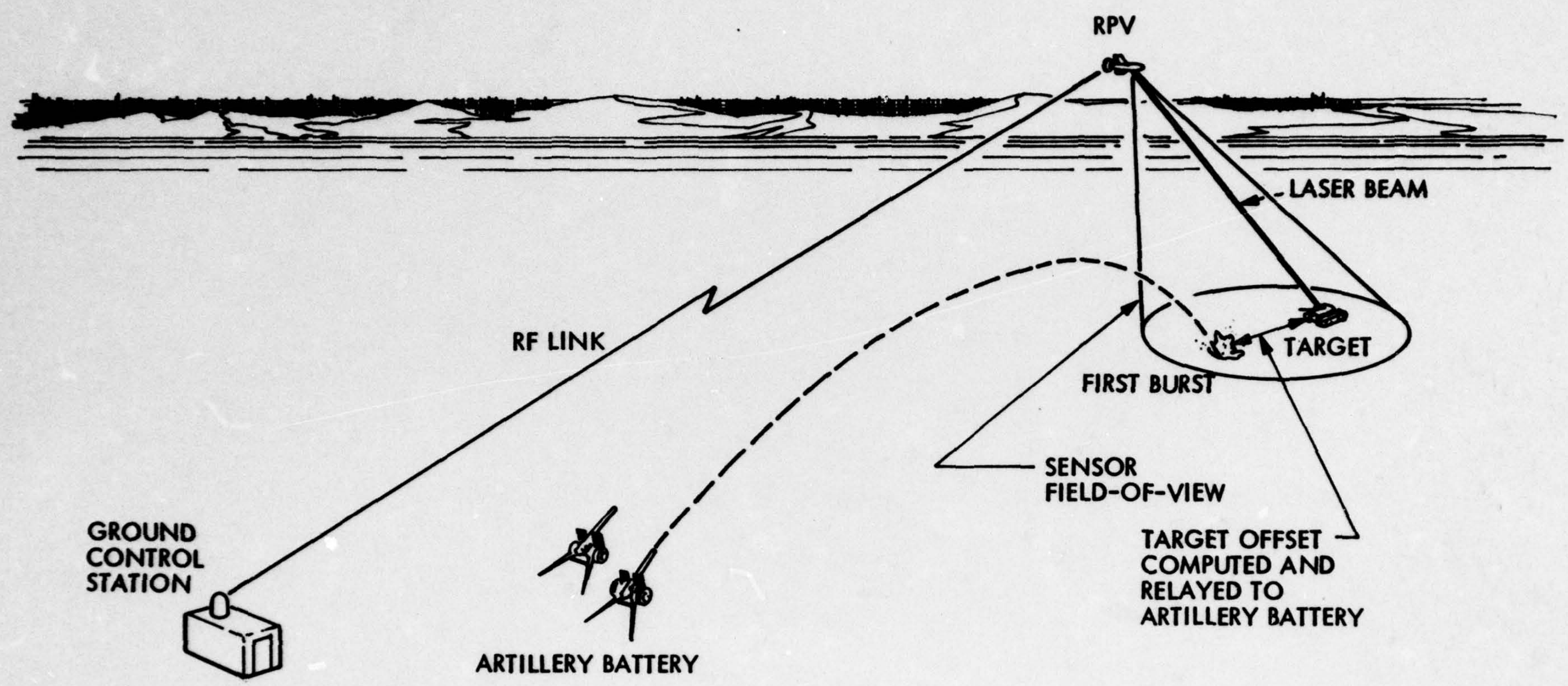

FIGURE 1-1

RPV CONFIGURATION

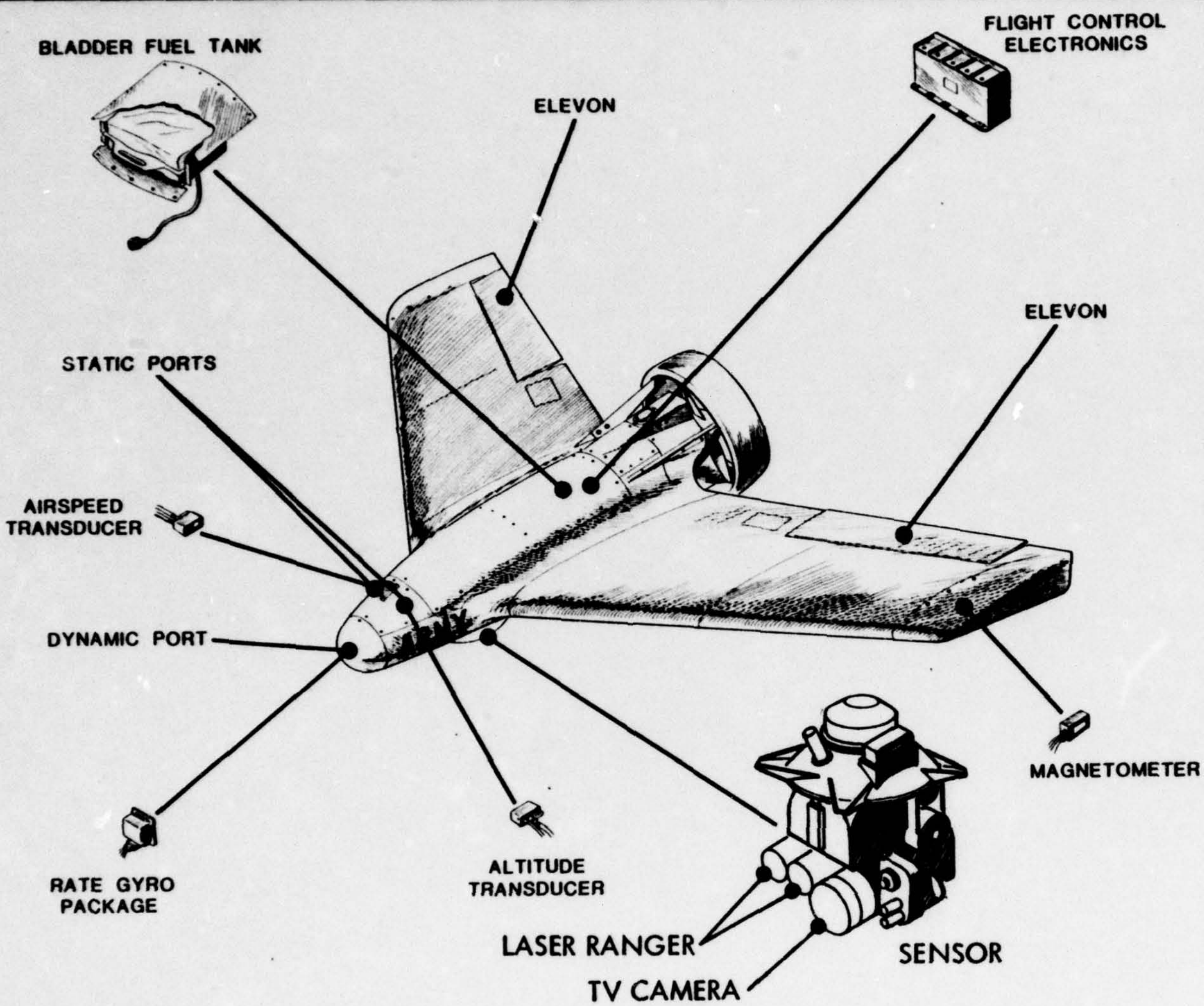

Figure 1-2

COOPERATIVE TARGET

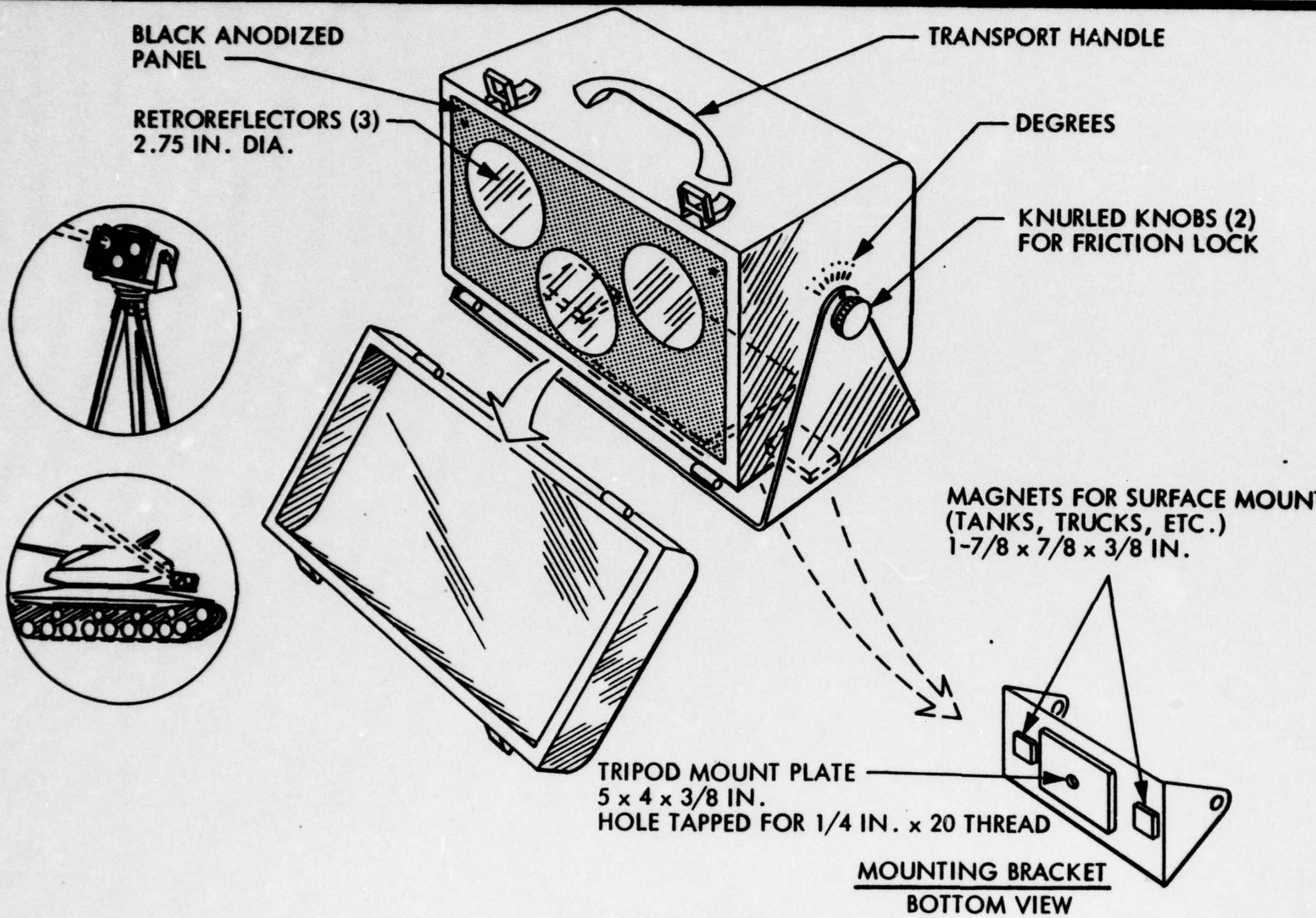

Figure 1-3

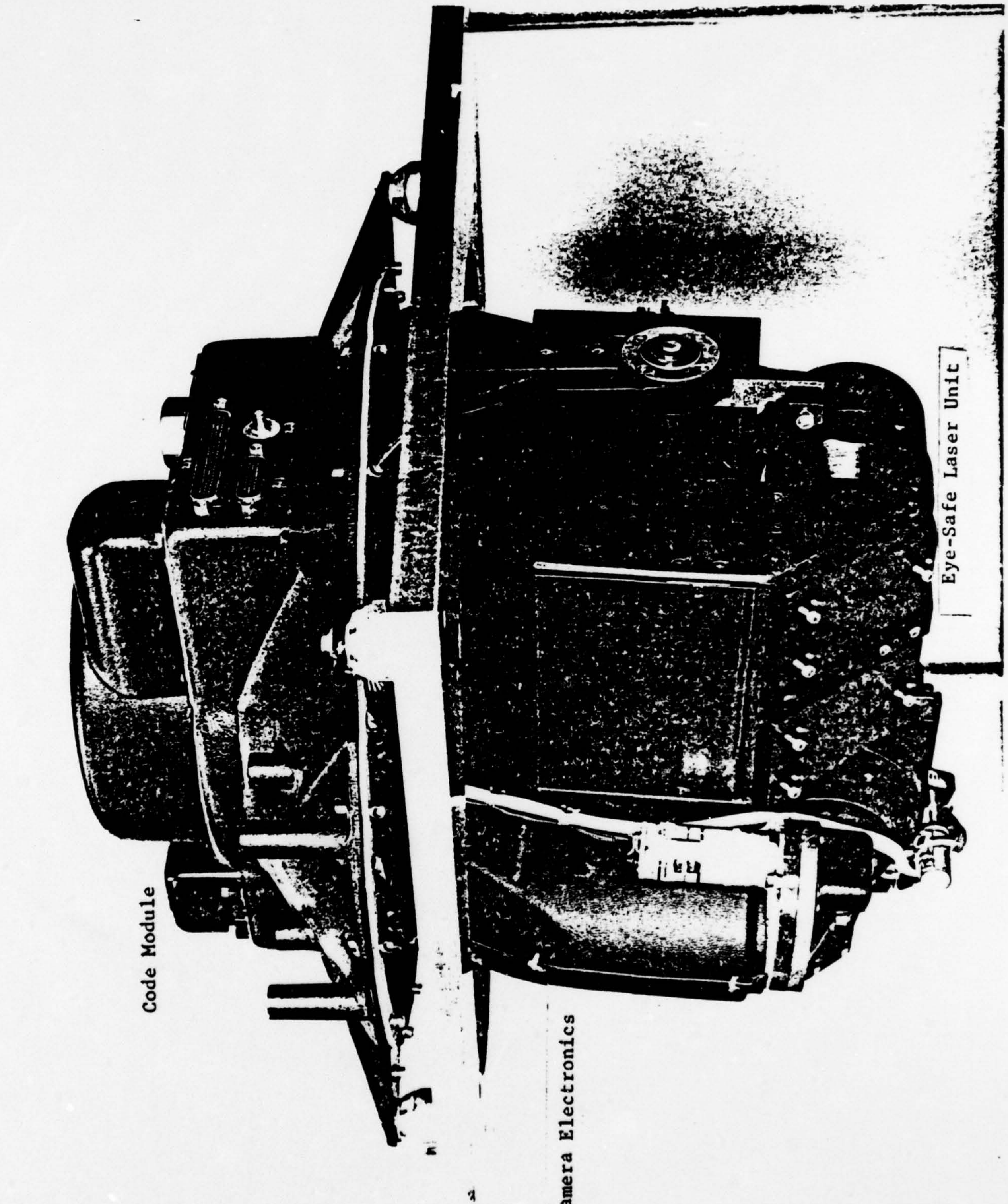

Figure 1-4 AQUILA PHASE IV/V SENSOR

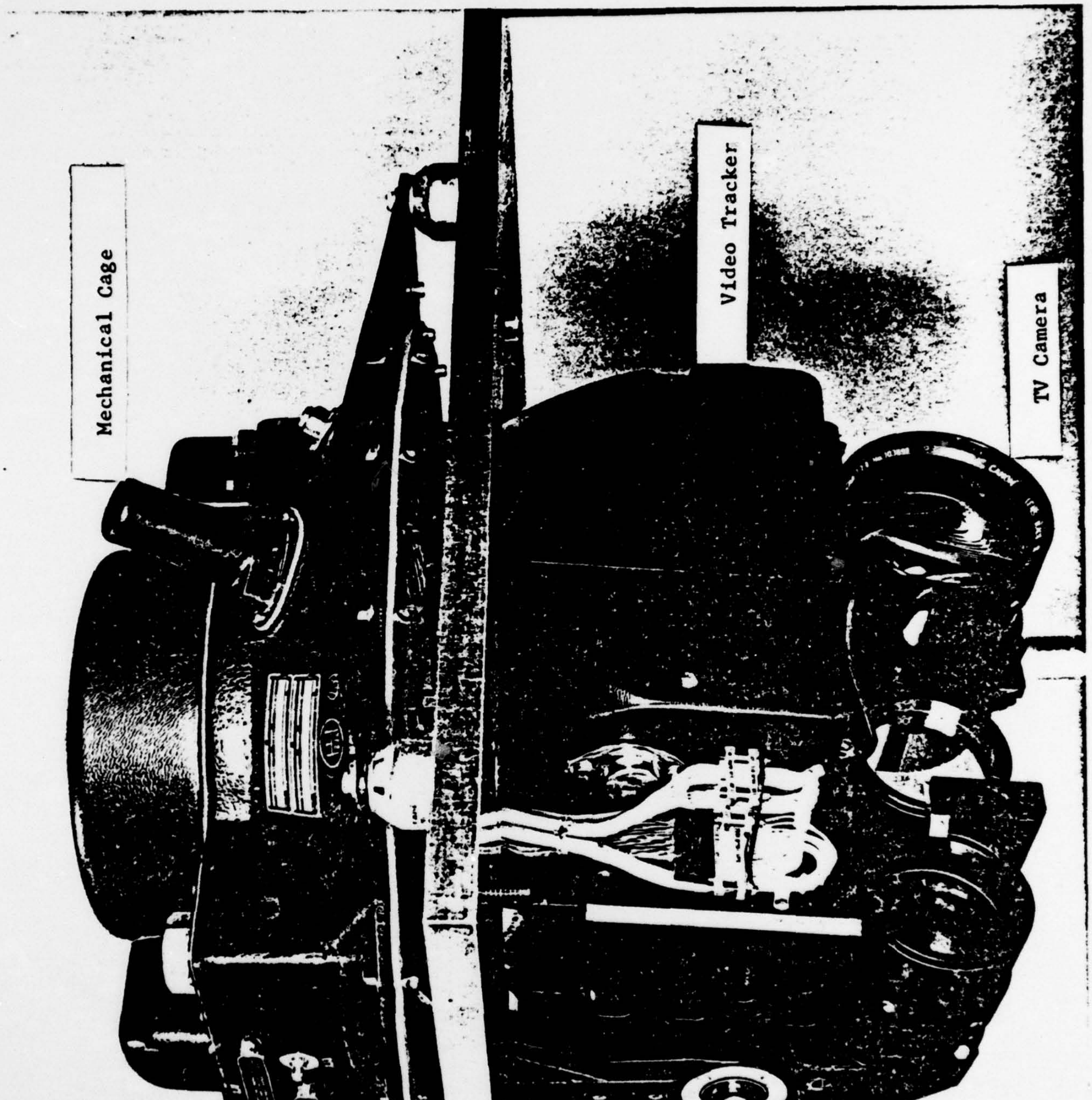

Figure 1-5 AQUILA PHASE IV/V SENSOR

Section 2

SPECIFICATIONS

The specifications of the ranging system delivered is as follows:

SYSTEM PERFORMANCE

o Maximum operating range	3,000 meters
o Minimum operating range	50 meters
o Acceptance angle of target	$\pm$ 45° at 3 Km (horizontal/vertical)
o Accuracy	$\pm$ 5 meters
o Resolution	5 meters
o Sample Rate	25 per second
o Duty cycle	Continuous

TARGET

o Apertures	2.875 inch per cube
o Configuration	3 retroreflector array
o Deviation accuracies	2 arc seconds
o AR coating	905 nanometers magnesium fluoride

LASER TRANSMITTER

o Source type	G_aA_s injection diode laser
o Wavelength (λ)	905 nanometers
o Source size	4 x 4 mils
o Peak power (output)	8 watts
o Pulse width	20 nanoseconds
o Pulse repetition rate	25 pulses per second
o Beam divergence	1 millirad
o Exit diameter	2 inches

RECEIVER

o Detector type	Avalanche photodiode
o Diode diameter	10 mils
o Responsivity	0.14V/μW
o NEP	1 nanowatt (50 MHz)
o Bandwidth electrical	30 MHz
o Bandwidth optical	200 Å

INTERFACE

o Input power	+28 VDC, ± 4 VDC
o Input current	300 milliamps
o Logic	+5 volts, C-MOS compatible
o Input signal Z	51 K ohms
o Output range word	11 bits serial, MSB first
o Output signals	Range word, laser fire and laser enable
o Input signals	Clock, enable, laser fire

Section 3

HARDWARE DELIVERED

Figures 3.1 through 3.14 are block diagrams and photographs of actual hardware delivered.

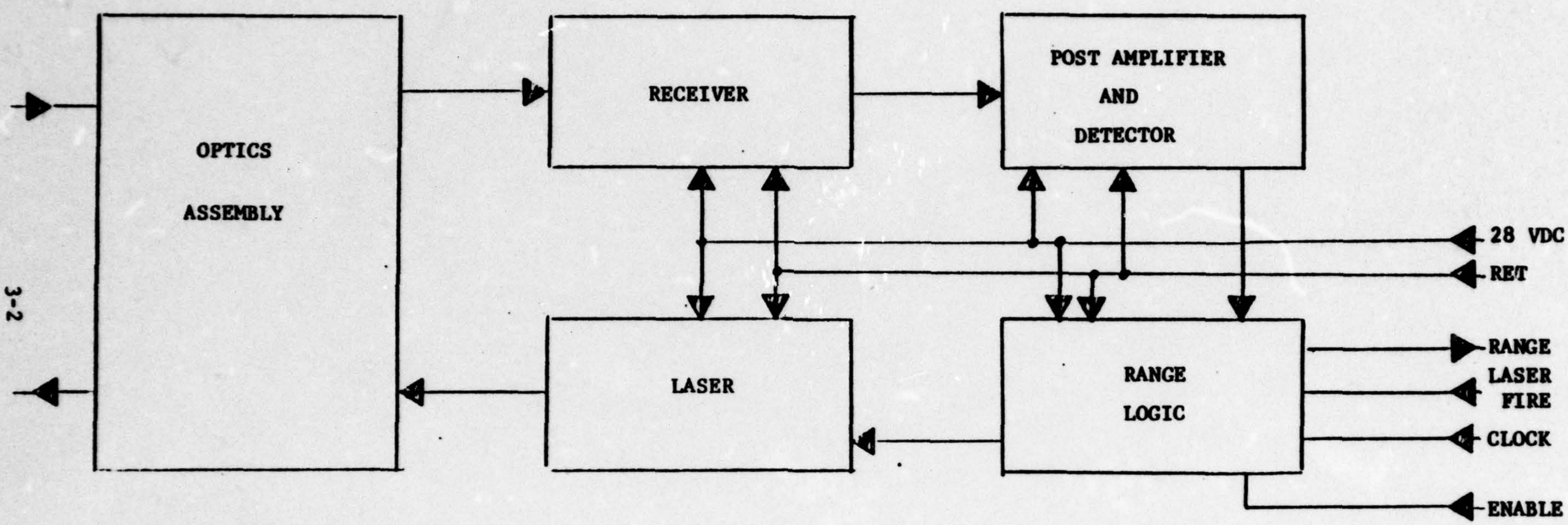

Figure 3.1 SYSTEM BLOCK DIAGRAM

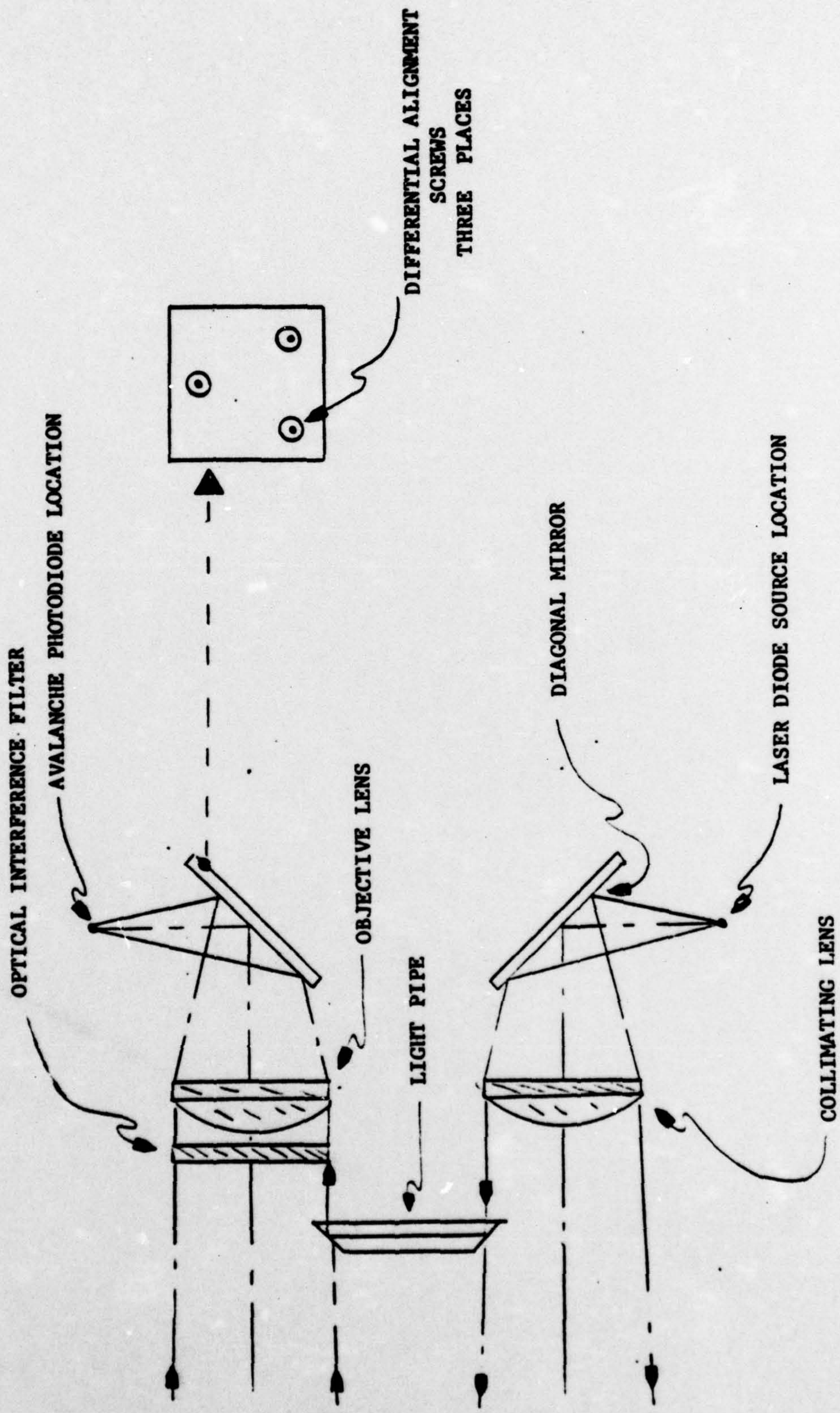

Figure 3-2 OPTICS ASSEMBLY

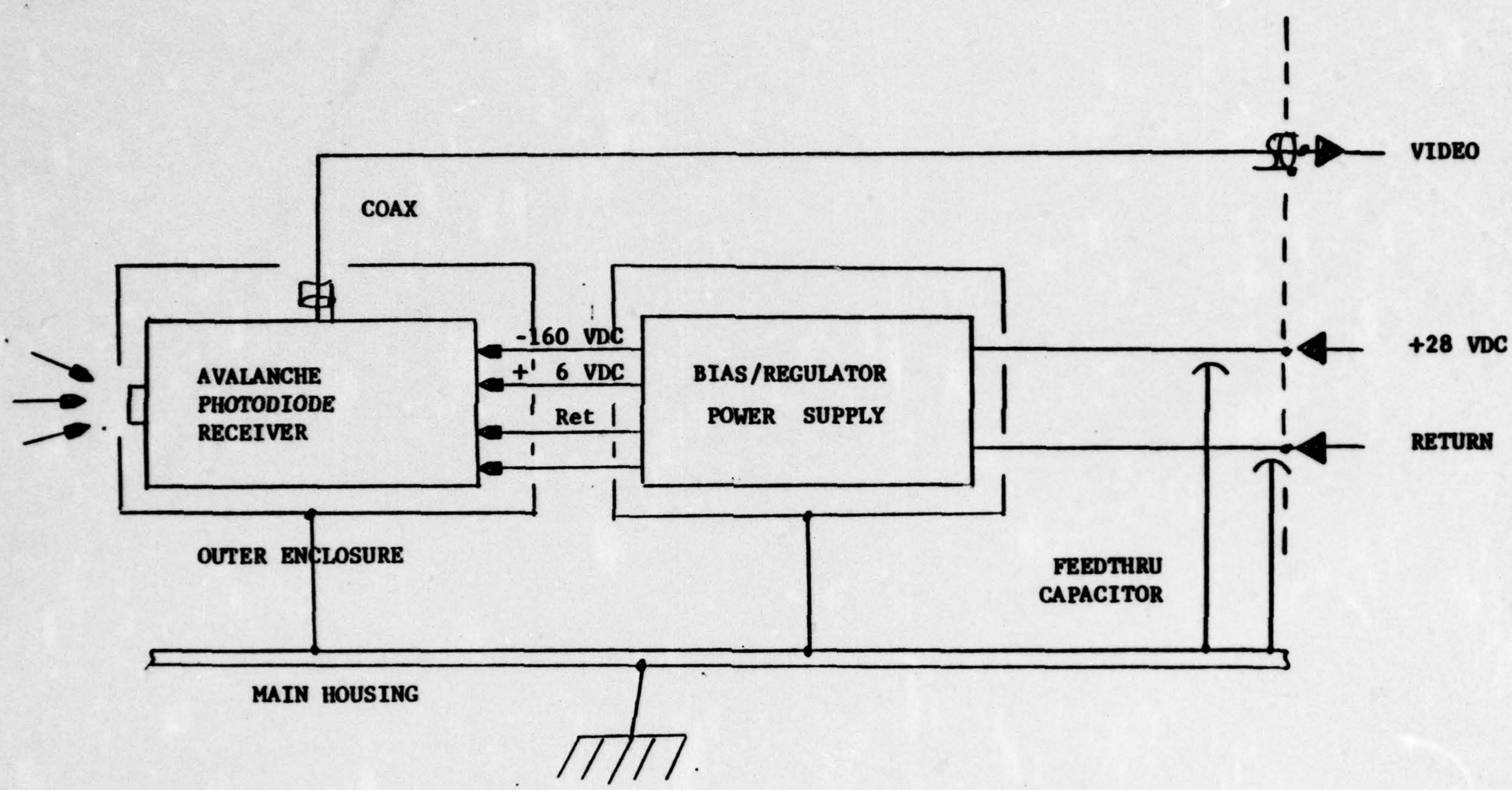

Figure 3-3 RECEIVER

Figure 3-4 PHOTODETECTOR MODULE ASSEMBLY

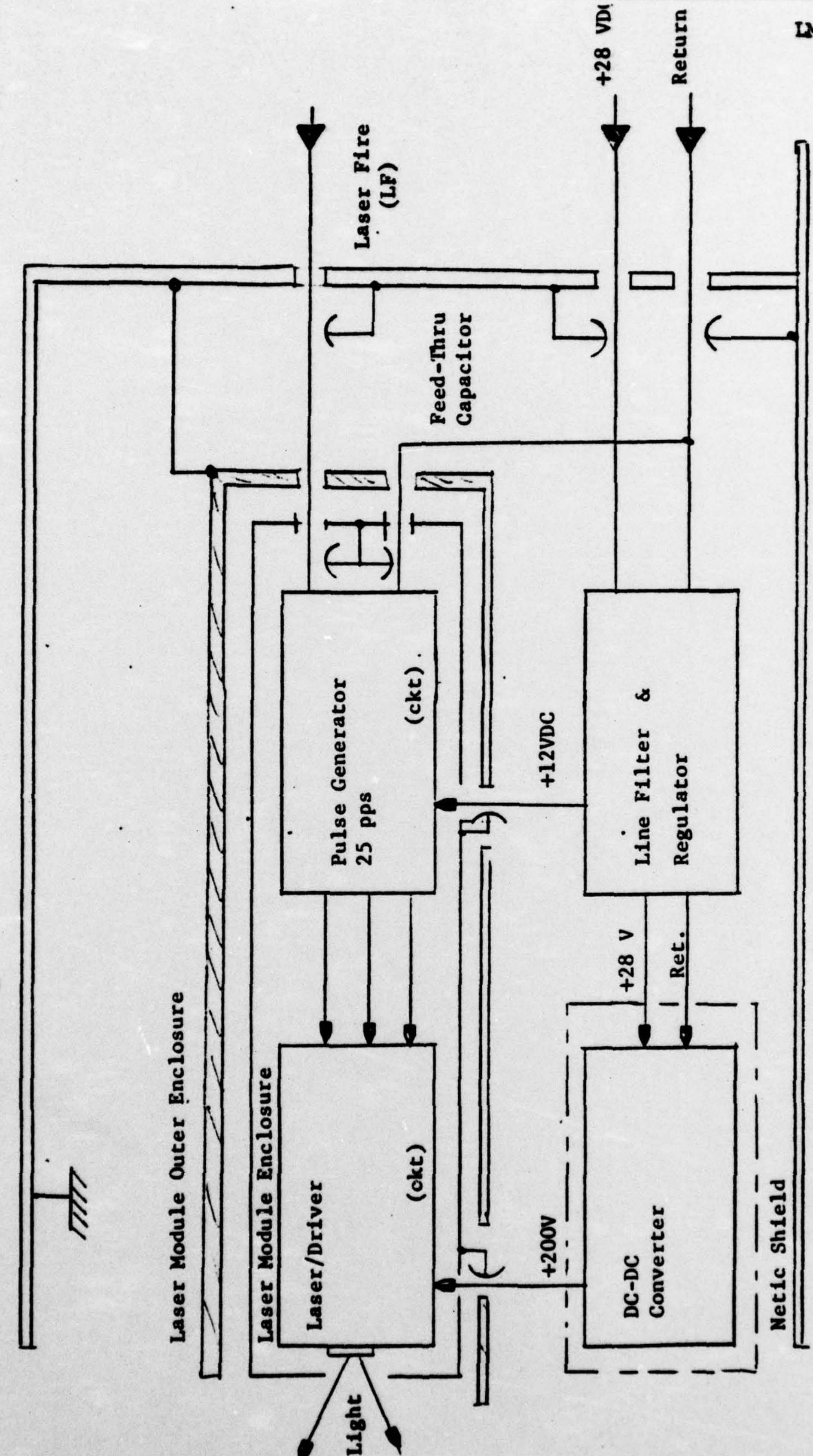

Figure 3.5 LASER

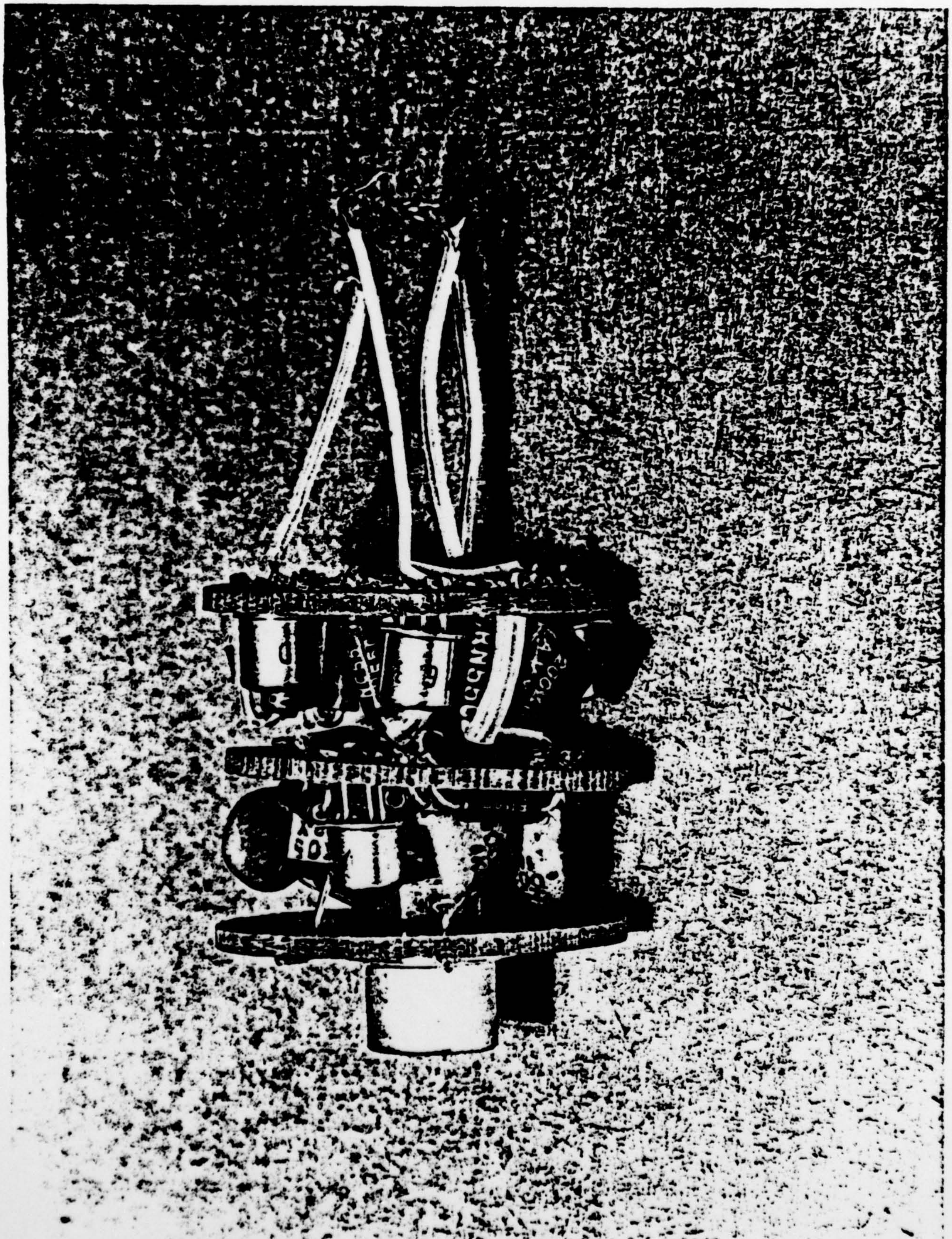

Figure 3-6 LASER ELECTRONICS

Figure 3-7 LASER MODULE

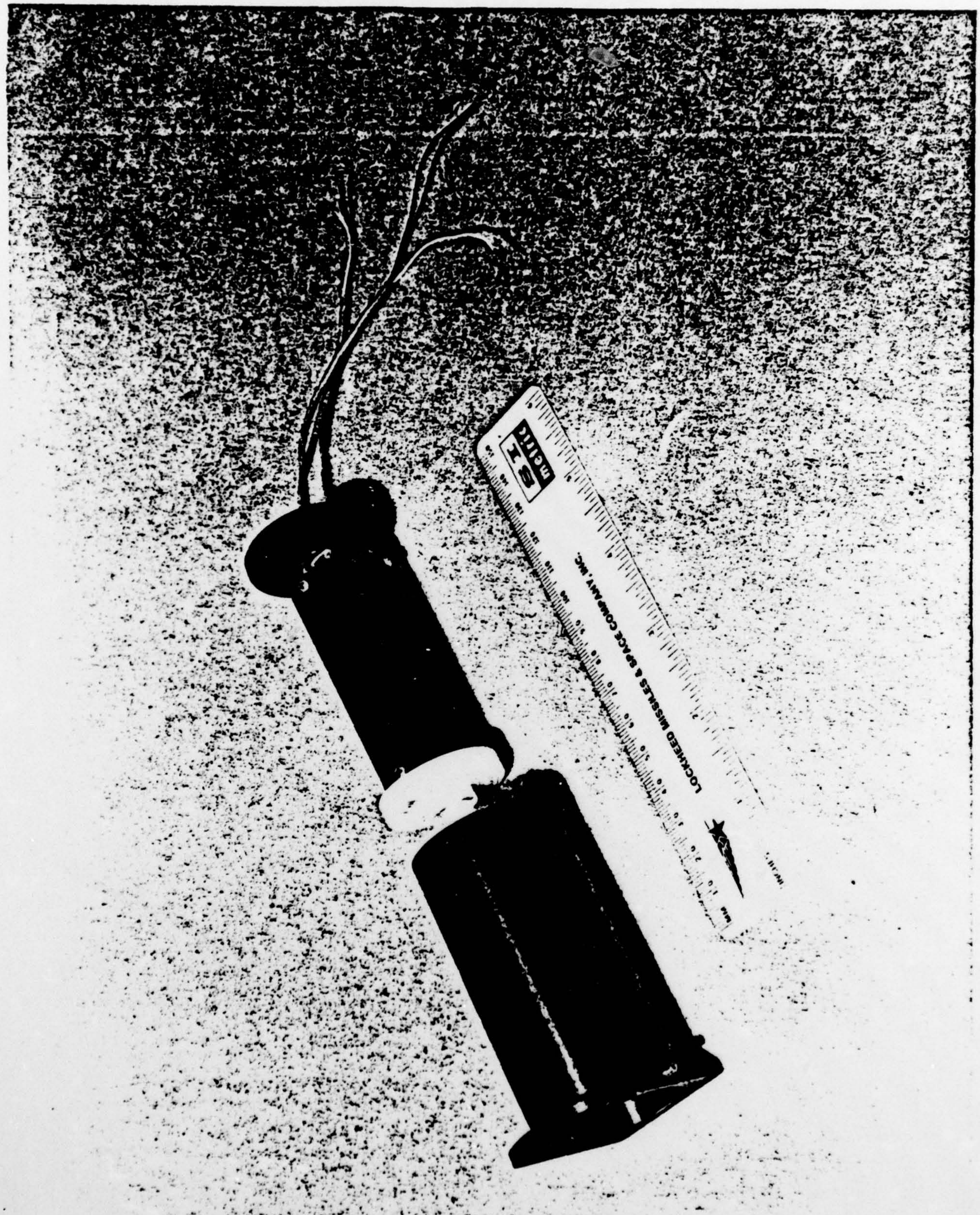

Figure 3-8 LASER ASSEMBLY

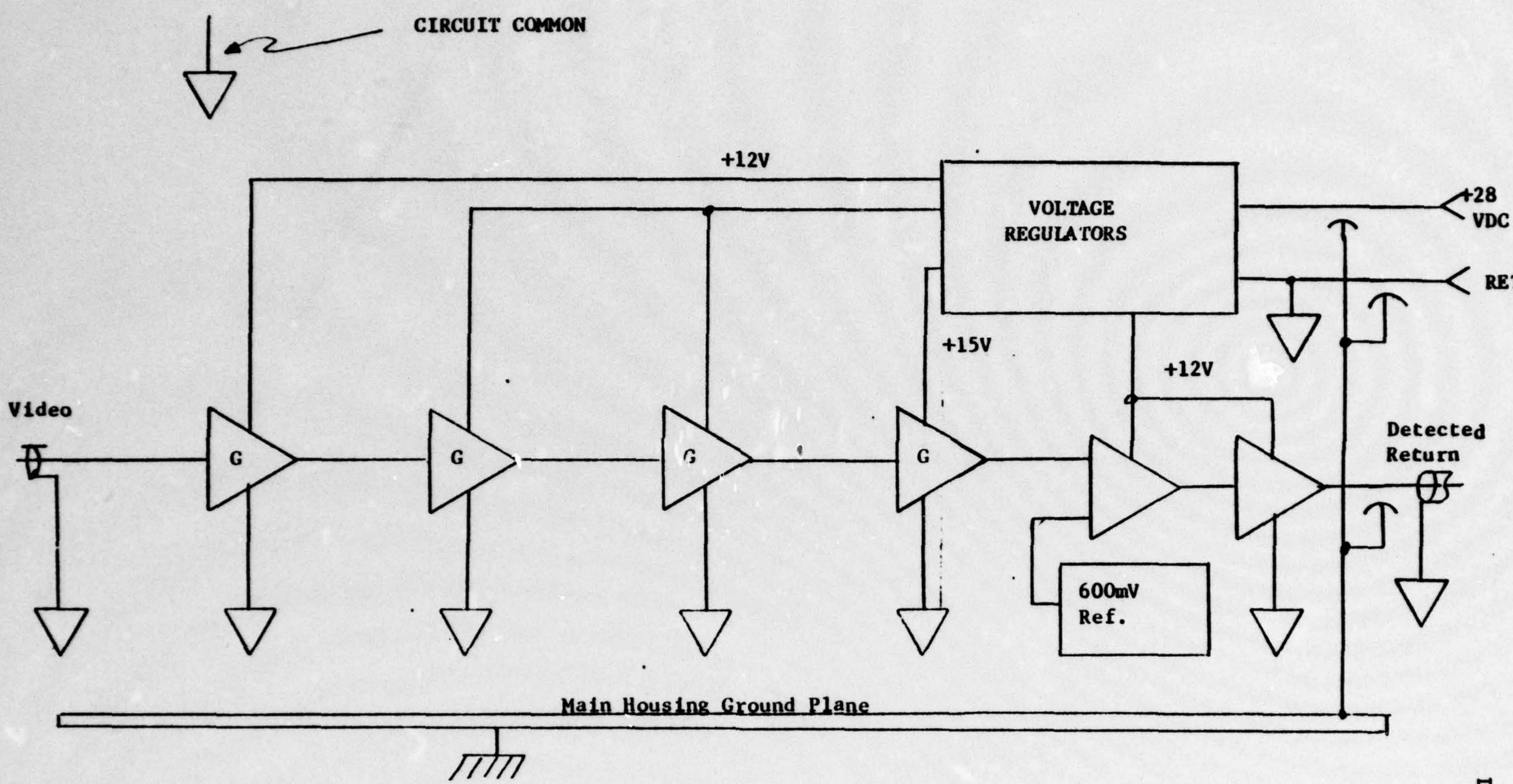

Figure 3-9 POST AMPLIFIER/DETECTOR ELECTRONICS

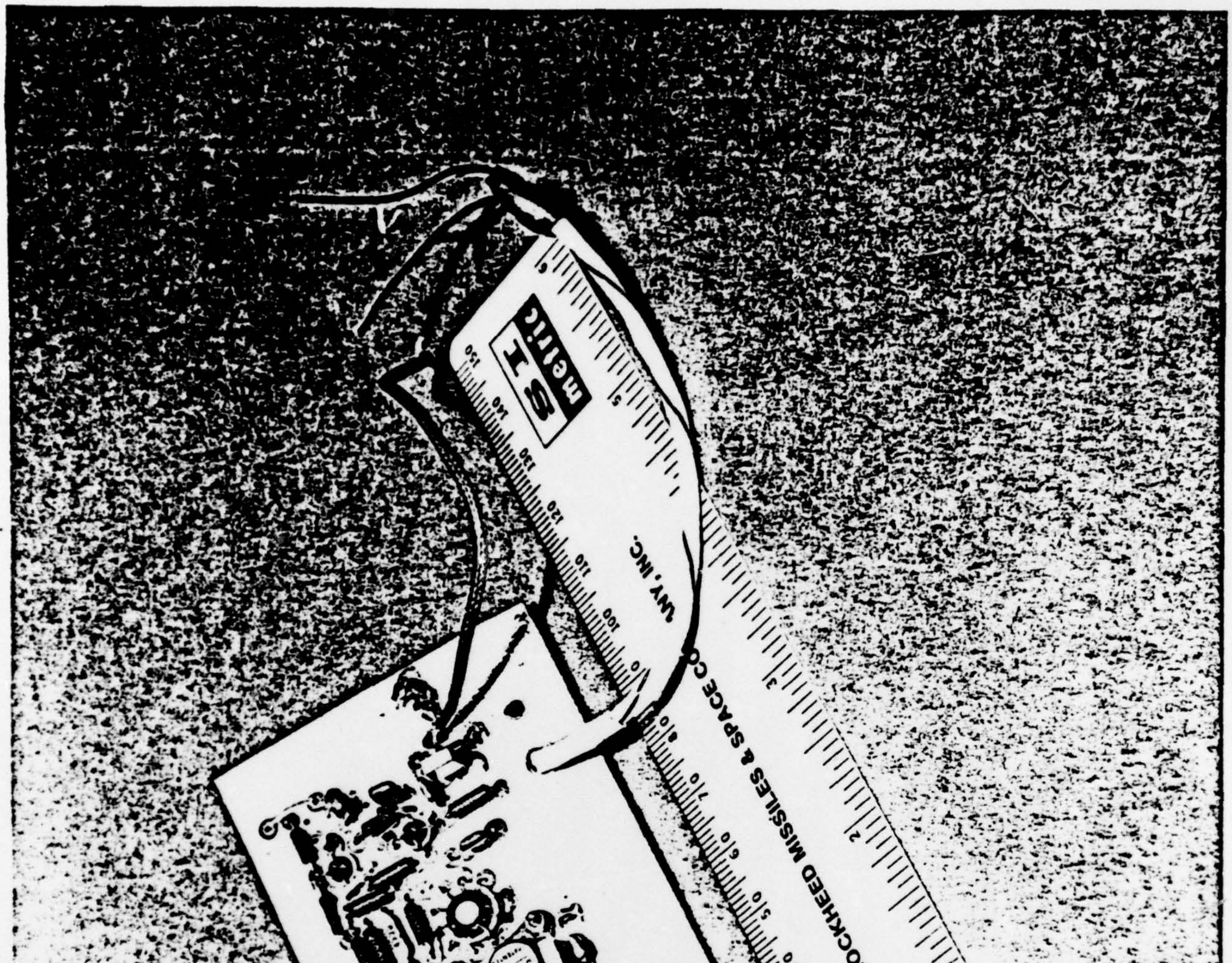

Figure 3-10 PULSE POST AMPLIFIER/DETECTION ELECTRONICS

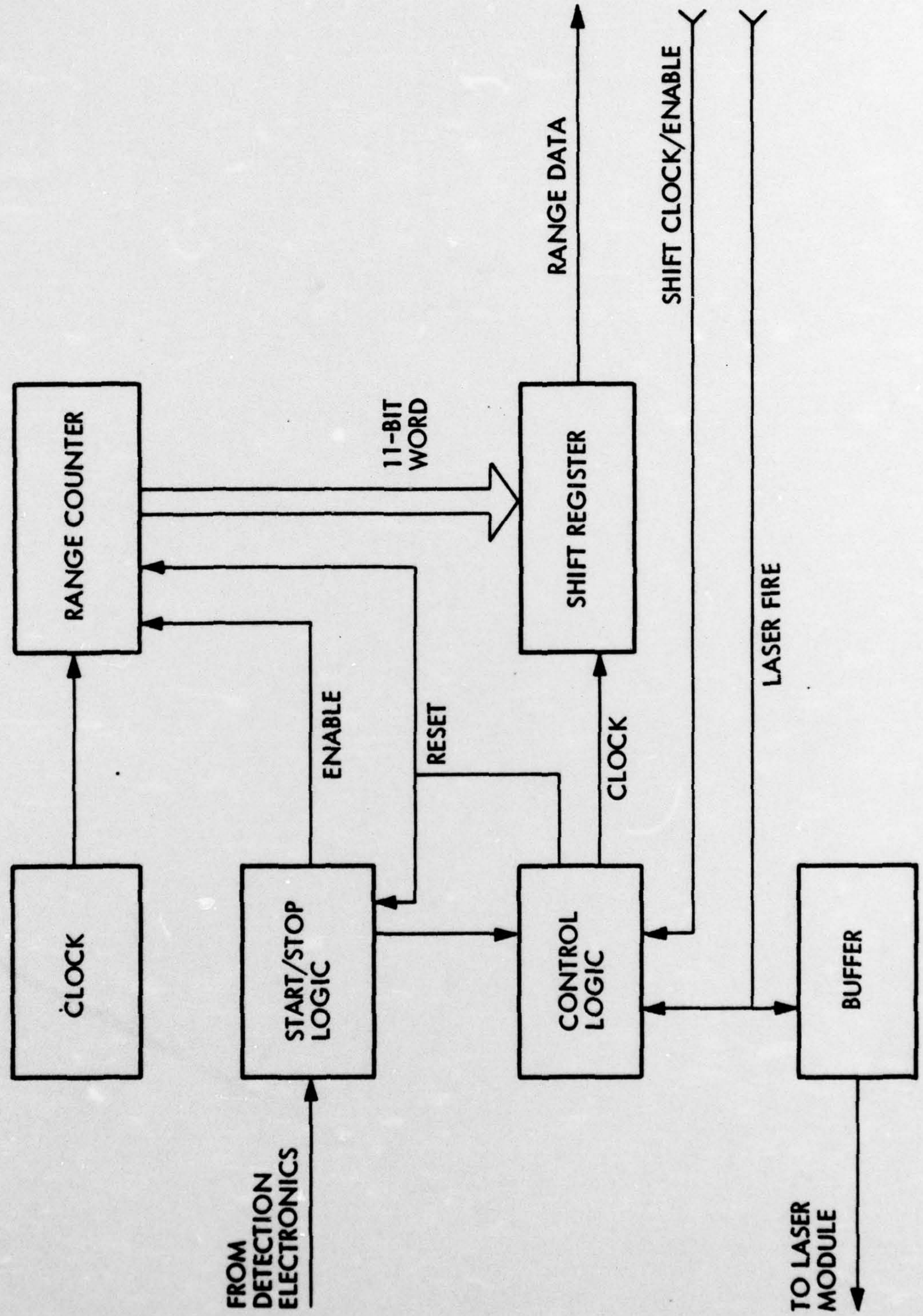

Figure 3-11 RANGE PROCESSING LOGIC

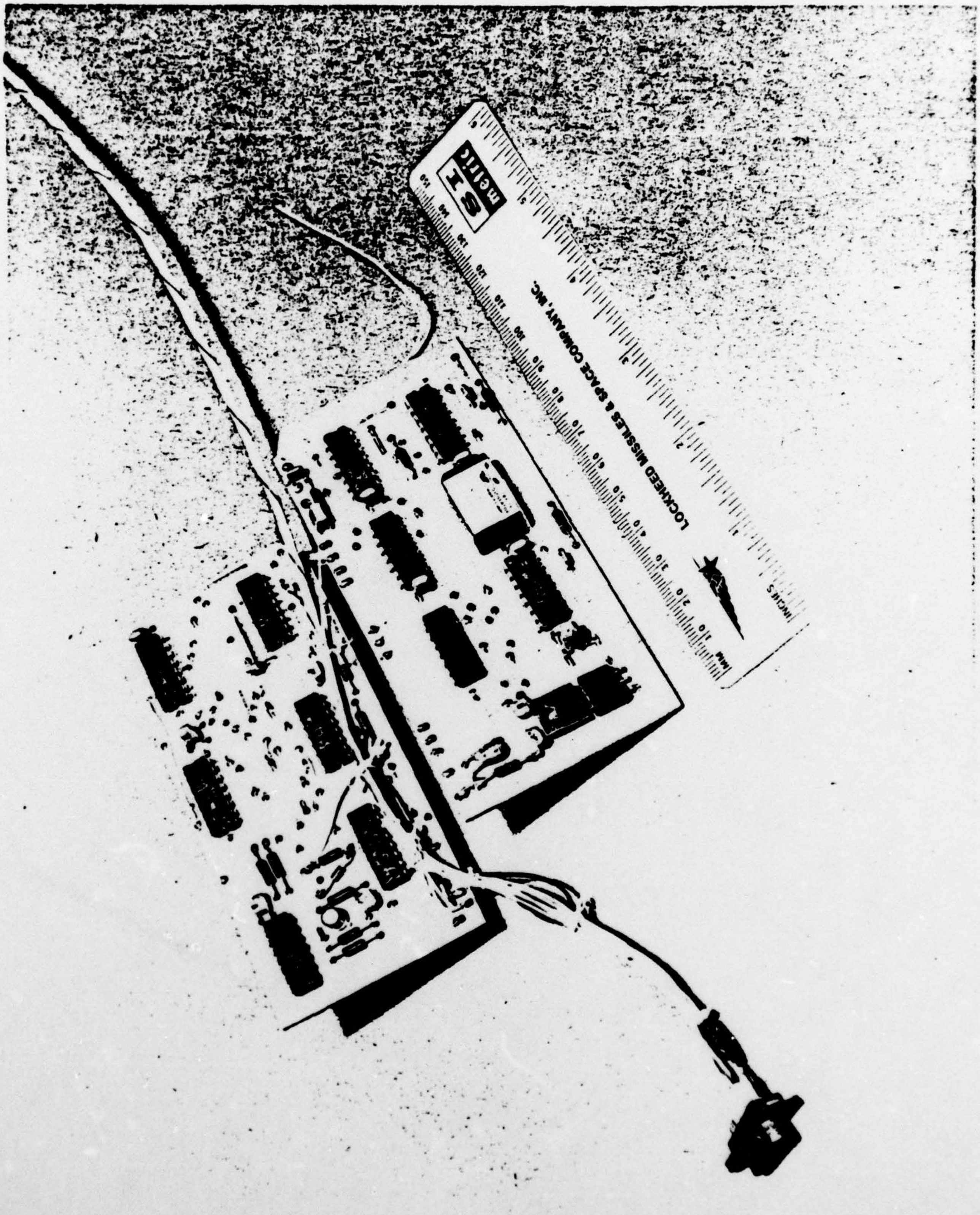

Figure 3-12 RANGE PROCESSING LOGIC

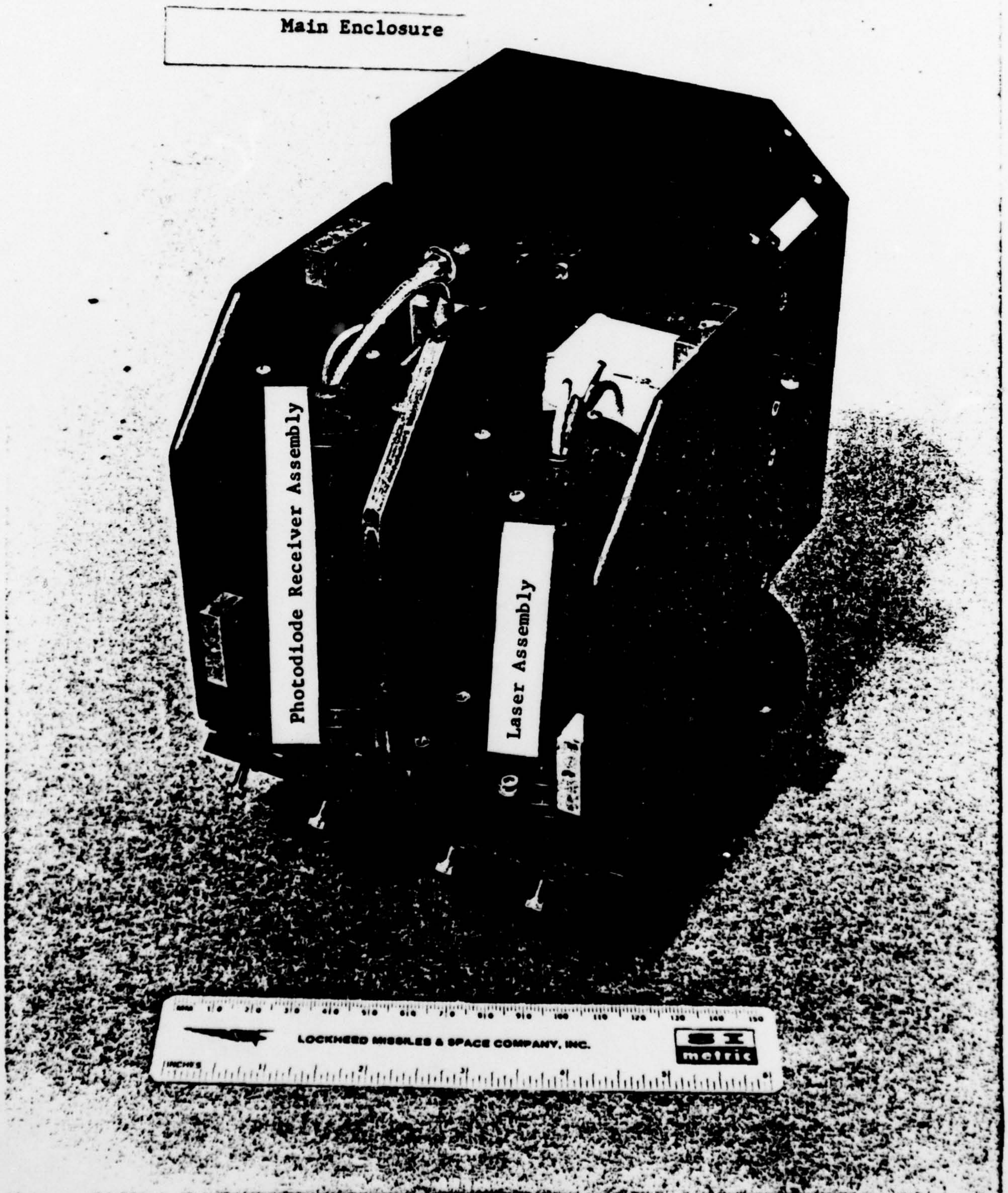

Figure 3-13 EYE-SAFE RANGING UNIT

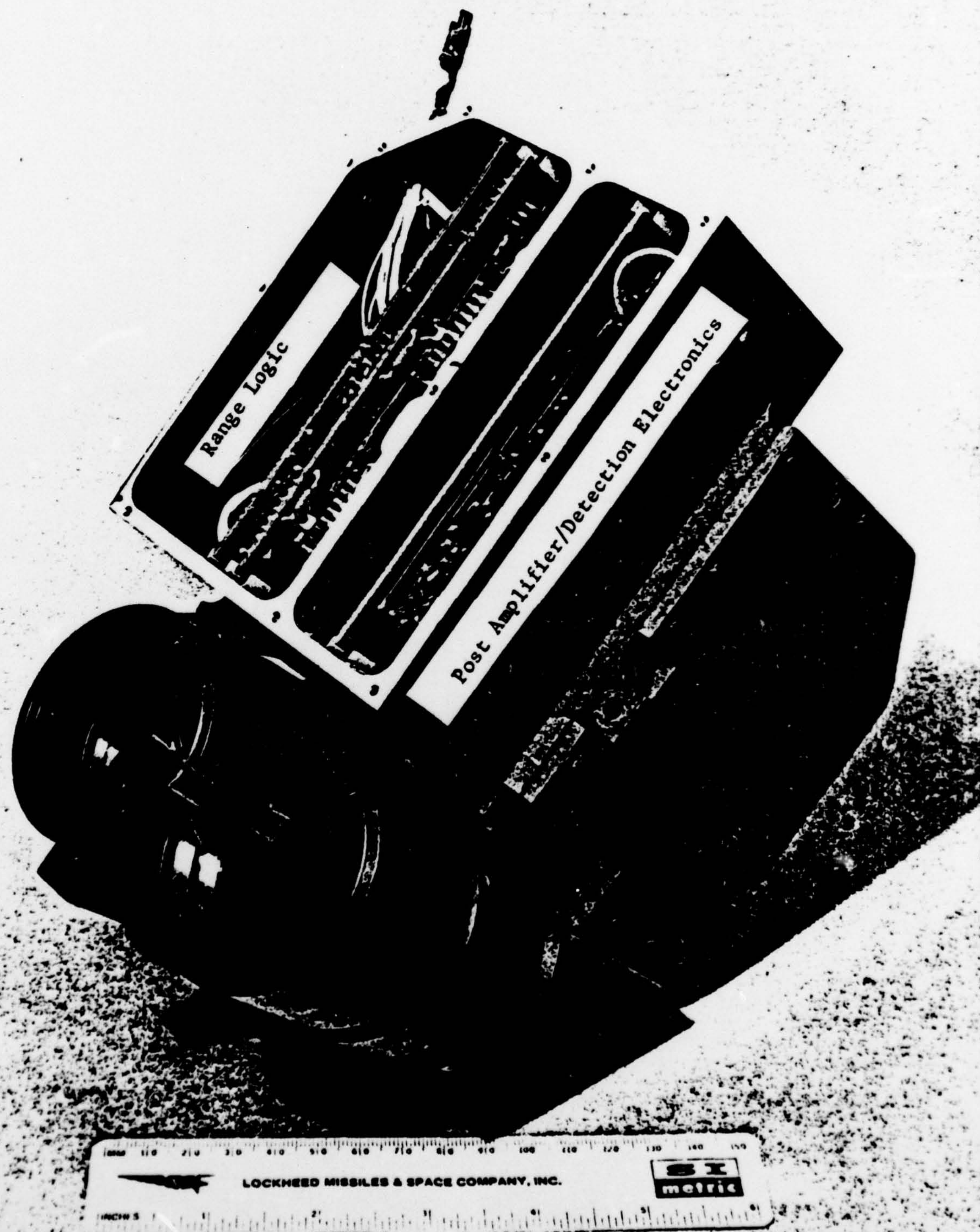

Figure 3-14 EYE-SAFE RANGING UNIT

Section 4
SAFETY STATEMENT

Aquila Eye Safe Laser

4-1 Introduction

The combination of an Aquila RPV with a Phase 4 and 5 high-power YAG laser has many safety problems associated with inadvertant laser emission coupled with possible uncontrolled unmanned flight. To overcome these problems, the eye-safe laser has been built to be directly interchangeable with the YAG laser unit in the Aquila sensor package. This eye safe laser will be used for training missions and initial Phase 4 and 5 flights. Coupled with a cooperative target the eye safe laser system will provide very realistic Aquila/laser system operational evaluation.

4-2 System Description

The eye safe laser is an injection type, repetitive pulsed, Ga As laser operating at a wave length of .905 um. It is a very low power (8 watts peak, 12 u watts average) with a pulse length of 20 nonoseconds or a pulse energy of 1.5×10^{-7} joules. The beam has a one m-rad divergence. These parameters place this laser in the ANSI standard Z 136.1 (American National Standard for the Safe Use of Lasers) Class I category or very safe laser.

The laser transmitter unit and the receiver unit are mounted in a rugged, anodized aluminum frame. Each have individual alignment adjustment trains. The laser transmitter and receiver assembly has its own power supply with electrical power obtained from the RPV aircraft system.

As assembled, the eye safe laser subassembly is fully enclosed except for one 8 pin connector. The maximum voltage inside the unit is 200 volts DC for the laser and for the receiver, 150 V. DC. The one lead for each of those high voltages is insulated and is fully enclosed inside the outer cover of the unit.

The electronics section of the unit is also enclosed with a cover. There are no voltages over 24 volts in the electronic section.

The mechanical design of the unit has considered good design practices. There are no sharp edges; the structure is mechanically sound. The eye safe laser unit is designed to exactly replace, mechanically, the Phase IV and V YAG in the Minneapolis-Honeywell POISE Sensor package.

Electrically the eye safe laser will be quite similar to the YAG laser. It will have an electronic DC power supply instead of a self contained battery but the eye safe laser will be isolated from the aircraft electrical system through the same protective circuits built into the sensor package. Electrical failures in the laser/sensor package should not jeopardize the safe operation of the RPV. The electrical isolation protection for the aircraft is considered adquate.

The personnel protection is also considered quite adequate. Placards indicating that the system is a Class 1 laser and that high voltage is present will be placed on the outer container of the laser. However, it is understood that only LMSC trained personnel will perform maintenance on any portion of the sensor package. The external surfaces of the sensor package are completely safe from any electrical or mechanical hazards.

The electrical connectors have been designed to preclude any misconnections by size or pin geometry or cable length. Normal care is required to perform an adequate preconnect inspection to insure that pins are not bent nor debris lodged in either portion of the connector. No lethal voltages are present on any pin (no voltages in excess of 24 volts).

There are no unique operational procedures associated with the eye safe laser itself.

4-3 Safety Conclusions

The RPV sensor package with an eye safe laser installed is safe to both personnel and the RPV under the following conditions.

a. There is no electrical shock hazard unless special, longer test cables are constructed which permits the sensor unit to be operated in a disassembled condition. All maintenance on the system shall be done by qualified personnel using approved procedures.

b. The sensor package shall always be handled with extreme care, always with a lens dome protective cover in place.

c. All mirror train alignment should be done only by qualified personnel.

d. The maximum hazard associated with the equipment is from improper maintenance or inadequate care.

e. The electrical protection system for the RPV shall be verified to be in operating order prior to each flight. Under no circumstances shall the sensor package result in loss of RPV control capability.

f. Emitted laser radiation is completely eye-safe and is classified as a Class I laser, therefore, exempt from operational restrictions.